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AUTHOR(S):

Nagatani, Takashi

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DLAフラクタルと相転移

静岡大学　工短大　長谷　隆

DLA fractal and structural phase transition

Takashi Nagatani
College of Engineering,Shizuoka University

We present a modified DLA model in which a structural phase transition occurs. We consider a directional solidification of binary mixture. The model is represented by the diffusion equation with temperature-dependent diffusivity. The governing equations are given by

$$\partial/\partial x_i [D(T)\partial C/\partial x_i]=0 \quad (1)$$

with $D(T)=D_0+\gamma T$,

$$\partial^2 T/\partial x_i^2=0. \quad (2)$$

We perform the simulation for pattern formation by using a biased-random walker. Figure 1 shows the patterns obtained by the simulation. For $\gamma>0$ flat-dense pattern appears, for $\gamma=0$ DLA fractal and for $\gamma<0$ a needle structure. We find the structural phase transition with changing the sign of γ. The flat-dense pattern is constructed by an assembly of needles with a flat envelope.

We also study the stability of the flat interface by using the linear stability theory. It is found that disturbances on the flat interface become stable with lower wavenumber than a critical value k_c and unstable with higher wavenumber for $\gamma>0$

$$k_c=(2L)^{-1}\ (\gamma\Delta T/D). \quad (3)$$

The critical wavenumber is proportional to the degree of supersaturation ΔT and γ.The hydrodynamic instability is related with the structure of the flat-dense pattern. On the other hand

for $\gamma<0$ disturbances on the flat interface become unstable for any modes. The morphological transition from the dense aggregate, through the DLA fractal, to the needle structure is consistent with the hyrodynamic instability.

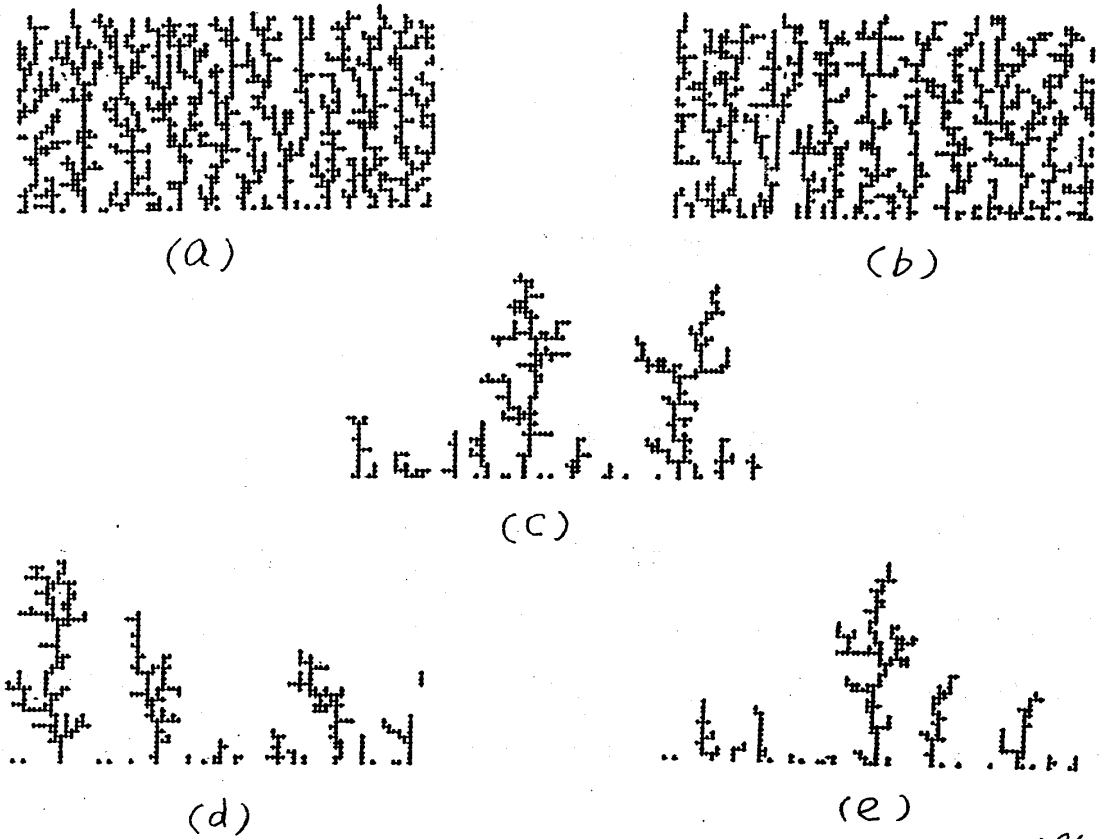

Fig. 1. (a) $\chi(\equiv \gamma\Delta T/D)=56$ (b) $\chi=40$ (c) $\chi=0$ (d) $\chi=-2.4$ (e) $\chi=-4.0$

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